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Missouri-Marias Basin, Voldseth Dams and Reservoir, Meagher County, Montana, MT-1153, MT-1590

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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MISSOURI - MARIAS BASIN
VOLDSETH DAMS AND RESERVOIR
MEAGHER COUNTY, MONTANA
MT-1153
MT-1590

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PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

GEORGE VOLDSETH
(OWNER)

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PREPARED BY:
HOSKINS - WESTERN - SONDEREGGER, INC.

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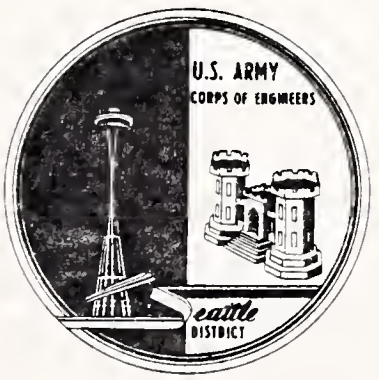

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers and with representation from the State of Montana Department of Natural Resources and Conservation and the owner, Hoskins-Western-Sonderegger, Inc. (HWS) inspected the two dams at Voldseth Reservoir on 9 May 1979 under the authority of Public Law 92-367. Voldseth Reservoir is located in Meagher County, Montana, approximately 10 miles southwest of Martinsdale. The reservoir has a natural drainage area of 1.0 square mile and a surface area of about 108 acres with a maximum possible storage of 1925 acre-feet. The reservoir is used for irrigation, stock watering and recreation. Two dams form the impoundment, a small dam on the east and a larger dam on the west. As design plans were not available for review, the safety evaluation is based only on the field inspection and review of hydrologic and hydraulic data. Findings were compared to engineering criteria currently accepted by most large engineering firms and governmental agencies engaged in dam design, construction, and operation.

PRINCIPAL FINDINGS AND EVALUATION

In accordance with the Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the two dams forming Voldseth Reservoir are classified as intermediate size. The West Dam (MT-1153) has a high downstream hazard potential. The East Dam (MT-1590) has a significant downstream hazard potential.

On the basis of its physical condition, the West Dam is designated as an unsafe dam-emergency condition. The East Dam does not meet inspection guidelines with respect to spillway adequacy.

Two slope failures in the downstream face of the West Dam, the high phreatic surface, the volume of seepage emerging at and above the downstream toe, the sloughing of the downstream toe, and the low strength of the clayey to sandy silt embankment materials indicate a safety factor against shear failure for the steady state seepage condition seriously less than the 1.5 recommended by the guidelines. The safety factor is more nearly 1.0, and this dam, under full pool conditions, could be in imminent danger of failure which would endanger lives and cause extensive damage to private residential property, ranch buildings, State Highway 294, and possibly a railroad.

The PMF routing shows the spillway located near the right abutment of the East Dam will handle 41 percent of the PMF total flood volume and 44 percent of the PMF ordinates before overtopping the East Dam, when the outlet pipe is closed. The routing further shows that the West Dam will not be over-topped during the PMF. Inspection guideline spillway recommendations are based on the downstream risk of dam failure. Therefore, this project must have capability to safely handle flood inflows to protect the West Dam against overtopping during a full PMF and East Dam against one-half PMF. The PMF is the flood expected from the most severe combination of critical meteorlogic and hydrologic conditions that are reasonably possible in this region.

The upstream faces of both dams show erosion by wave action where there is no riprap above the high-water line. The affected areas include the entire length of the East Dam and roughly half the length of the West Dam. Overall riprap coverage is inadequate. Trees and brush are standing at the high-water line on both dams. However, most of the small trees and brush are dead, having been sprayed with brush killer in 1978. Several large trees remain alive on both dams.

All exposed surfaces of both dams show extensive burrowing by rodents. In erodible materials, such as the clayey to sandy silt out of which the embankments are built, rodent burrows become a considerable threat to the integrity of an embankment dam.

PRINCIPAL RECOMMENDATIONS

Immediately develop, implement and periodically test an emergency warning plan to alert downstream interests below both dams in the event of dam failure from either overtopping or structural conditions.

Take immediate action to correct the unsafe condition of the downstream face of the West Dam. Maintain reservoir level at least 18 feet below the crest of the West Dam until the West Dam stability has been made adequate. We recommend this work be accomplished by an engineer experienced in dam design and construction.

Conduct field studies, laboratory tests, and engineering studies of embankment stability and modify the project as required to provide for a safety factor of at least 1.5 for the steady state seepage condition for both dams. In any modification of the dams consider the possibility of earthquake-induced shear failure or liquefaction of the embankment or foundation materials. Conduct more-detailed hydrologic and hydraulic routing studies to better determine the downstream hazard potential and required spillway capacity, and modify the project as studies indicate.

Stephen H. Nickel
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal ID. No.	MT-1153 (West Dam) MT-1590 (East Dam)
Owner	George Voldseth
Operator	George Voldseth
Purpose	Irrigation, Stock Watering, Recreation
Location	Meagher County, Montana
Watershed	Trib. to South Musselshell River
Downstream Hazard Potential	MT-1153 (West Dam) Category I (High) MT-1590 (East Dam) Category II (Significant)
U.S.G.S. Quadrangle	Lennep, Groveland, Rimrock Divide and Lebo, Montana (7.5 min.)

2. RESERVOIR

Surface Area at Normal Pool	108 Acres
Normal Storage (Spillway Crest)	1574 Acre-feet
Total Storage (East Dam Crest)	1925 Acre-feet
Surcharge Storage	350 Acre-feet
Drainage Area	1.0 square mile
Reservoir Water Surface Elev. (9 May 1980)	5495.6 feet NGVD

3. SPILLWAY (East Dam)

Type	Earth and cobble channel
Crest Elevation	5507.8 feet NGVD
Width	20 feet (average)
Spillway Capacity (East Dam Crest)	100 cfs

4. OUTLET WORKS

	WEST (MT-1153)	EAST (MT-1590)
Type	Controlled Corrugated Metal Pipe*	
Controls	Square slide gate with vertical access tower and manual control from dam top*	
Size	18-inch diameter*	
Inlet Invert	5483.0 feet NGVD	5501.0 feet NGVD
Outlet Invert	5483.0 feet NGVD	5488.5 feet NGVD (approx.)
Normal Tailwater	5481.0 feet NGVD	Unknown
Discharge Capacity (East Dam Crest)	20 cfs	15 cfs

* Applies to both dams

5. DAM	WEST (MT-1153)	EAST (MT-1590)
Type	Earth	Earth
Maximum Height	35 feet	24 feet
Crest Length	2200 feet	1150 feet
Crest Elevation (Min.)	5514.2 feet NGVD	5511.0 feet NSVD
Crest Width	16 feet	20 feet
Upstream Slope	Varies	Varies
Downstream Slope	Varies	IV on 2.3H

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope.

This report summarizes the Phase I inspection and evaluation of the Voldseth Reservoir Dams, owned by George Voldseth of Lennep, Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume I of the U.S. Army Corps of Engineers' Report to the United States Congress on National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phased study procedure for investigation and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam.
(2) based upon an evaluation of the available data and a visual inspection.
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted.
(4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer

serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rest with the dam owner and the State of Montana. Prior to any action to implement report recommendations, the owner is urged to contact the Montana DNR&C. It should be noted that nothing contained in the National Dam Inspection Act, and neither action nor failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-federal interests.

1.1.3 Inspection

The findings and recommendations in this report were based on visual inspection of the project and an interview with the owners. No design drawings or foundation exploration results were available for review or analysis. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the inspection included:

Louis Boitano, Civil Engineer, Corps of Engineers

Lawrence Tegg, State of Montana, Department of Natural Resources and Conservation

George Voldseth, Owner

Gary Voldseth, Owner's Son, Operator

Hoskins-Western-Sonderegger, Inc. (HWS) personnel who participated in the field inspection and contributed to this report are:

Stephen Nickel, Geotechnical Engineer, Team Leader

Richard Walker, Hydrologist/Hydraulics Engineer

This report has been reviewed by the owner and the Montana DNR&C, and their comments are attached in Appendix A.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Voldseth Reservoir is an off-channel irrigation storage impoundment for water diverted from Comb Creek. It is located in Section 8, Township 7N, Range 10E, Meagher County, Montana, approximately 10 miles southwest of Martinsdale on an unnamed tributary of Comb Creek. The reservoir results from the construction of 2 dams, West Dam (MT-1153) and East Dam (MT-1590). The reservoir behind West Dam extends to the drainage divide, and at the divide the low dam (East Dam) permits the reservoir level to be higher than the elevation of the divide. The West Dam has a high, or Category 1, hazard potential in case of failure due to the presence downstream of 4 houses and Montana Highway 294. The hazard rating of East Dam is significant or Category 2 due to the presence downstream of 1 inhabitable structure. The lake has a surface area of 108 acres, with storage at the spillway crest of 1574 acre-feet. The local drainage area is approximately 532 acres. The diversion canal inlet is at the left abutment of the West Dam. The project's spillway, generally 20 feet wide, is in the right abutment of the East Dam. Both the East and West Dams have low-level 18-inch-diameter corrugated metal pipe gated outlets for irrigation purposes.

1.2.2 Regional Geology

The drainage area of the Musselshell River is a region of basin and range complicated by thrust faulting. Geographically, the Big Snowy Mountains and the Little Belt Mountains are on the north, the Crazy Mountains are on the south, the Castle Mountains are in the middle, and the Big Belt Mountains are on the west, forming a semicircle of mountains around a group of basins extending generally eastward onto the great plains.

Before the late Cretaceous, this was an area of quiet basinal sedimentation. Pre-Cambrian, Paleozoic, and Mesozoic sedimentation produced sandstones and shales. These Pre-Cambrian and Lower and Middle Paleozoic sedimentary and metamorphic rocks are exposed in the mountains and are only exposed due to the mountain-building that occurred here.

During late Cretaceous times and Tertiary times, three possible phases of mountain-building seem to have occurred: (1) initial Cretaceous uplift of the Central Montana arch; (2) late Cretaceous thrust faulting (as evident west of the White Sulphur Springs area) which produced attendant normal and high-angle reverse faulting, with fracture faulting also common; and (3) Tertiary igneous activity which involved the formation of the Castle and Crazy Mountains. The igneous rocks are alkalic and are composed of syenites and other alkalic-rich varieties. With the intrusion of the igneous bodies and the thrust faulting, the older Pre-Cambrian and Paleozoic rocks were uplifted and exposed as in the case of the Big Belt Mountains. The attendant foothills of the ranges are of later Paleozoic and Lower Mesozoic sediments.

During this mountain-building phase, the basinal sediments were formed into a dome containing smaller anticlines and synclines. The most prominent of these are the Little Belt Mountains and the Snowy Mountains.

Subsequent to the mountain building came erosion. Erosional debris from the mountians swept down by rivers and streams covered the earlier Cretaceous sandstones and shales and formed the Eocene Fort Union formation, consisting of sandstone, shale, and bituminous coal.

Subsequent erosion of this domed basin has produced the present topography which shows a rim of Fort Union deposits with succeedingly older Cretaceous deposits toward the center of the present smaller basins. These Cretaceous deposits are predominantly the sandstones and shales of the Livingston Formation. The oldest formation exposed in the basins is the Colorado Shale. Later Tertiary gravels and sands form the terraces and benches of the Musselshell River with Pleistocene alluvium along the recent bed of the river.

1.2.3. Seismicity

The reservoir and dams lie in Seismic Zone 3 as indicated by the Seismic Zone Map (Reference 1). The seismic probability of Zone 3 is one of a potential for major damage and is based on the know distribution of damaging earthquakes in the region. Although the Zone Map is based on a known distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design parameters for this site.

No major faults have been mapped in the immediate vicinity of the reservoir, although the traces of minor faults can be inferred from aerial photographs and topographic maps. No active faults were found or inferred at the reservoir site. The Geologic Map of Montana identifies 3 faults at a distance of 4 to 6 miles west of the reservoir and one 6 miles east.

Epicenters of local earthquakes significant enough to be reported in References 12 and 13 occur approximately along a line from 20 miles northwest of Helena to 25 miles north of Bozeman. The 3 largest reported earthquakes along this line have had intensities of VIII (Modified Mercalli). One of these earthquakes had its epicenter at a point 25 miles north of Bozeman, (27 June 1925), while the other two occurred at Helena (18 October and 31 October 1935). Of these 2 epicentral areas, the former is 45 miles and the latter 80 miles from the reservoir. No reported earthquakes have occurred at distances of less than 45 miles from the reservoir.

1.2.4 Site Geology

Voldseth Reservoir appears to lie in a south-plunging syncline, in the Livingston formation. The axis of the syncline runs through the reservoir. The hills to the north of the reservoir are a surface expression of the syncline. Comb Creek, south of the reservoir, roughly parallels the synclinal axis. Near the reservoir, the creek is diverted to the northwest (see Photo 1) along what appears to be a wrench fault which crosses the syncline. The offset along this fault is not large, and the fault does not appear to be active. Tertiary or quaternary alluvium generally overlies the bedrock in the Comb Creek valley. The alluvium consists of clayey to sandy silt with some gravel and cobbles. The alluvium appears

to be thin (less than 15 feet thick) along the north side of the reservoir and thickens toward the south. Weathered shale is exposed in a borrow area along the north side of the reservoir.

1.2.5 Design and Construction History

At the time of the inspection, George Voldseth stated that the West Dam was 41 years old and that there had been no design or construction assistance from any agency or any engineer. Selective placement was used in the original construction with the more impermeable material in the upstream and the more permeable material in the downstream section. According to Mr. Voldseth, the height of the dam was raised approximately 10 feet in about 1954. The original conduit was said to be welded steel pipe, but the existing outlet is corrugated metal pipe. It is speculated that the corrugated metal outlet pipe was added to the conduit when the height of the dam was raised.

The East Dam was constructed at the time the West Dam was raised to prevent water in the reservoir from escaping over a drainage divide. The spillway in the right abutment of the East Dam also was constructed at that time. No plans or other construction records are available.

CHAPTER 2

INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillways

The outlet channel which functions as a spillway is located at approximately the right abutment of the East Dam of Voldseth Reservoir. The spillway channel has eroded to its present condition by previous usage. The present condition of the channel is best shown on Photo 16. Approximate dimensions and elevations were determined in the field for purposes of hydraulic calculation of discharge capacity for this spillway channel.

The approach channel to the control section is approximately 150 feet in length until it joins the reservoir. The general slope of the invert varies from zero to an adverse slope of 1.0 percent. The configuration of this approach channel is very irregular as can be seen from the photographs. The channel is clear of any heavy or dense growth and has eroded and will continue to change configuration when subjected to future flows.

The safety and integrity of the East Dam embankment and abutment is not jeopardized by the erosion which has and may continue to occur in the spillway channel.

The spillway channel invert slope averages 5 percent downstream from the control section. The channel bends in approximately a semicircle away from the dam until it reaches the natural stream channel at a distance of approximately 200 feet downstream from the East Dam. The location of the spillway control section was determined by computing critical depth and normal depth for the range of discharges sustained by the spillway. This showed that supercritical flow occurred over this range of discharges downstream from the control section. (See Plates 3 and 4 for the spillway configuration.

The discharge rating for the spillway was computed by assuming critical depth to occur at the control section and then computing water surface profiles upstream into the reservoir. A Mannings roughness coefficient, "n", of 0.045 was assumed for the backwater computation. The discharge of the spillway at the low point on the East Dam, elevation 5511.0 feet, is 100 cfs.

The spillway discharge rating curve is shown on Plate 6. Maximum discharge experience by this spillway is not known.

2.1.2 Outlets East and West Dams

The two dams forming the Voldseth Reservoir each have an operational low-level gravity outlet works. The outlet through the East Dam is an 18-inch-

diameter corrugated metal pipe with a vertical CMP stilling well for control access. Access to this outlet for inspection was difficult because of a snowbank covering the downstream outlet, and because the pipe inlet was surrounded by deep mud due to the low level of the reservoir. The general configuration of the East Dam outlet works was assumed to be similar to that of the West Dam. The assumed configuration for the East Dam outlet works is shown on Plate 2. The pipe inlet in approximately 10 feet below the minimum East Dam crest elevation. The pipe outlet is 22.5 feet below the minimum crest. The pipe inlet is 7 feet below the minimum crest of the spillway. The conduit was not inspected.

The West Dam outlet structure was inspected and measured. The assumed configuration is shown in a sketch on Plate 2. The west outlet pipe is also an 18-inch-diameter corrugated metal pipe. The pipe inlet invert is 28.0 feet below the East Dam minimum crest elevation, 31.2 feet below the West Dam minimum crest elevation, and 24.8 and 31.2 feet below the East and West Dam minimum crest elevations respectively. The conduit was not inspected. However, the outlet end had been bent downward by a small slope failure centered on the conduit (see Photo 5). The outlet has no energy dissipator.

The approximate discharge capacities of the combined east and west outlets are as follows: 30 cfs at the crest of the spillway; 35 cfs at the minimum crest elevation of the East Dam; and 40 cfs at the minimum crest elevation of the West Dam.

2.1.3 Irrigation Canal

The major source of runoff inflow to the Voldseth Reservoir is an irrigation supply canal, which in turn is fed by waters diverted from Comb Creek to the south and west of the reservoir. The maximum hydraulic inflow capacity of this canal is estimated to be 170 cfs from rough field measurements and USGS 7.5 minute topographic quadrangle maps. This flow is based on the assumption that there is no upstream control on the canal.

The minimum levee crest elevation on the downslope levee forming this irrigation canal is critical in determining the hydraulic and/or hydrologic safety of the Voldseth Reservoir system. The minimum crest elevation of this levee is approximately three feet below the average crest of the West Dam and approximately level with the minimum crest elevations of the East Dam (see Photo 9). The assumed effect of this channel reservoir configuration is that when the Voldseth Reservoir and its own tributary drainage area experience a thunderstorm, like the PMP (Probable Maximum Precipitation), the irrigation canal continues discharging to the reservoir until its own downslope levee is overtopped and fails near the left abutment of the west dike. This overtopping occurs at approximately the same time the East Dam overtops. If the canal levee fails, the canal ceases to flow into the reservoir and the breached levee then provides additional reservoir outflow capacity because its crest elevation is lower than both the East and West Dams. However, the worst condition would occur if the levee does not fail and this is the alternative which was assumed to

take place when routing the PMF. A breach of the levee would not endanger the embankment.

2.1.4 Freeboard

The vertical distance between water surface and crest of dam is 3.2 feet and 6.4 feet for the East and West Dams, respectively, at the normal pool elevation of 5507.8 feet. The fetch for wind-generated waves is approximately 2000 feet, and wave run-up and set-up on either embankment is estimated to be less than 2 feet (Ref. 3). Therefore, operational freeboard for normal pool conditions is considered adequate to prevent wave overtopping of either dam. Routings indicate that the PMF will cause the reservoir to rise to elevation 5503.0 feet, overtopping the East Dam and leaving 1.2 feet freeboard on the West Dam.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The climate of the area around Voldseth Reservoir is continental and characterized by a large diurnal and seasonal temperature range. Extreme variability of wintertime temperature results from the frequent occurrence of Chinook winds, which follow a Pacific Maritime airmass invasion. The summers are characterized by warm days with low humidity and cool nights. Winters are moderately cold and highly variable in severity from year to year and within a given year.

Martinsdale, in Meager County, is the nearest climatological station representative of the dam site and is located 10 miles to the northeast in the Musselshell Valley at 4800 feet elevation. Climatological data at this station is available for approximately 70 years. Mean annual precipitation at Martinsdale is about 15.0 inches. The average depth of snowfall at Martinsdale is 55 inches. This depth would be greater at Voldseth Dam because of the 600-foot difference in elevation. Over 60 percent of the precipitation falls from March through August. Mean February temperatures are 22 degrees F and mean July temperatures are 65 degrees F. Temperature extremes at Martinsdale are approximately -55 degrees F and 105 degrees F (Ref. 5). The average expected date of the last freeze is June 20th and the average first freeze is August 23 (Ref. 8).

The drainage basin above and including Voldseth Reservoir is 1.0 square mile and is elongated in the north-south direction. The basin must be considered in three separate components: the area north of the reservoir; the area south of the reservoir; and the reservoir water surface. There are no developed perennial stream channels on either the north or the south slopes. The average ground surface slope over both segments is 387 feet/mile. Basin elevations range from the reservoir normal pool elevation of 5507.8 to 5840 feet on the crest of the butte north of the reservoir and 5700 feet on the south area tributary to the reservoir. The vegation of the area is typical of the short grass plains. There is sparse pine

tree cover on the upper south slope. The Crazy and Castle Mountains lie to the southwest of the basin.

There is an irrigation canal which diverts flows from Comb Creek to the southwest of the reservoir entering the reservoir at the south abutment of the West Dam. The maximum hydraulic capacity of the canal was estimated as 170 cfs and its usual operational discharge at about 30 cfs. It appears to be the principal means of filling and regulating Voldseth Reservoir.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of about 108 acres and a storage of 1574 acre-feet at the assumed spillway crest elevation of 5507.8 feet. Approximately 350 acre-feet of storage are available between this spillway crest and the minimum crest elevation of the East Dam. The spillway discharge at the minimum crest elevation of the East Dam is 100 cfs. This discharge would increase an additional 35 cfs if both low-level outlets were opened.

Historic flood flows for the general area have occurred in the Shields River Basin, located 15 miles south, and on the North Fork of the Musselshell River, (same basin), where maximum floods of 20.2 cfs per square mile on 88 square miles and 13.5 cfs per square mile on 31.4 square miles, respectively, have been recorded (Ref 4).

2.2.3 Probable Maximum Flood

The probable maximum flood (PMF) is defined as the flood expected from the most severe combination of critical meterologic and hydrologic conditions that are reasonably possible in the region. A probable maximum precipitation (PMP) storm of 72-hour duration was applied to the basin. This storm was derived and patterned in the following manner. The 24-hour index, 12-hour, 6-hour, and 1-hour PMP depths were estimated from National Weather Service Technical Paper 38 (Ref. 6). The 48-hour and 72-hour PMP depths were taken as 110 percent and 115 percent of the 24-hour index PMP, respectively. All 6-hour increments from 0 to 72 hours were arranged in a critical order of occurrence.

The soil types prevailing in the Voldseth Reservoir Basin, as determined from References 5 and 9, are approximately 50 percent Hydrologic Soil Group (HSG) B and 50 percent HSG C. The recommended constant minimum soil losses of 0.15 inch/hr. and 0.08 inch/hr. were used for HSG B and C, respectively (Ref. 10). The effective constant loss rate for the basin was taken as the average of these two groups, or 0.115 inch/hr. No initial loss was subtracted at the beginning of PMP storm.

The overall configuration of the 72-hour PMP storm is as follows. The storm produces 8.5 inches in 1 hour, 13.3 inches in 6 hours, 17.2 inches in 24 hours and 19.8 inches in the total 72 hours. The soil losses computed under the above stated assumptions resulted in losses for 1-hour, 6-hour and 24-hour durations of 0.115 inch, 0.69 inch, and 2.76 inches. The net

runoff resulting from this rainfall was computed for the same three durations as 8.385 inches, 12.61 inches, and 14.44 inches. These net reservoir inflow runoff depths apply to the upland areas north and south of the reservoir. The net depth of rainfall on the reservoir surface itself is the same as the input PMP.

2.2.4 Flood Routing

The Probable Maximum Flood (PMF) inflow hydrograph to the Voldseth Reservoir was generated using the Mockes dimensionless SCS unit hydrograph. The drainage area for the basin is approximately 640 acres, 108 acres of which is water surface area at elevation 5507.8 feet. The runoff hydrographs were generated and combined using the HEC-1 (Dam Safety Version) computer program developed for hydrologic dam safety analysis (Ref. 11). The total volume of the PMF was 990 acre-feet with a peak flow of 7696 cfs occurring during the 40th hour of the 72-hour PMP storm.

The flood routing of the PMF was made using the modified Puls method contained in the HEC-1 program. The routing was made to define the total volume of the PMF and the volume of the PMF that could be handled by reservoir storage and spillway capacity before overtopping. The results of the routing show the East Dam and supply canal levee being overtopped in the 40th hour of the PMF and the percentage of the PMF volume either retained in surcharge storage or safely passed as 41 percent. Reservoir storage and spillway capacity is sufficient to handle 44 percent of the PMF ordinates without overtopping. The percentage of the PMF either retained in surcharge storage or safely passed would not increase significantly in the event that the supply canal levee would fail. The routing shows the West Dam will not overtop during the PMF.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam Embankments

The 35-foot-high West Dam has a crest width of 16 feet and a crest length of 2200 feet. The upstream slope is 1(V):2.6(H) and irregularly flatter near the crest. The downstream slope is 1(V):1.9(H) and slightly steeper near the toe. According to Mr. Voldseth, the embankment material is clayey to sandy silt with gravel and cobbles in the lower portion and similar materials with some weathered shale in the upper 10 feet. Varying slopes and crest elevations appear to be a result of construction. Variations in crest width have been caused by erosion, principally on the upstream face. The riprap protection in inadequate.

The 17.0-foot-high East Dam has a crest width of roughly 20 feet and a crest length of 1150 feet. The crest is very irregular, varying as much as 2.0 feet in height. Variations in crest width were not measured, but are estimated to be as much as ± 5 feet from the value state above. These variations seem to have been caused by erosion on the upstream face. Variations in slopes and in the crest elevations appear to be a result of construction. Riprap is inadequate.

Borrow for the West Dam was obtained from below the downstream toe. Additional borrow was probably obtained from the reservoir area. Some weathered shale was obtained from above the right abutment of the West Dam. The borrow source for the East Dam is not known.

2.3.2 Foundation Conditions, Seepage, and Drainage

The foundations of both dams appear to be composed of silts, gravels, and cobbles similar to the materials found in the embankments. The thickness of these alluvial and colluvial materials appears to increase from north to south, but the exact thicknesses are unknown. The foundation material is Comb Creek valley fill, the edge of which can be seen in a borrow pit at the north abutment of the West Dam.

The foundation alluvial silts, gravels, and cobbles are very permeable in their natural state, and only slightly less so when compacted as embankment. According to the owner, the dam embankments contain no internal drainage systems. Because of these facts, seepage or the vegetative evidence of seepage was found along almost the entire length of West Dam. The evidence of seepage consisted of greener grass and higher susceptibility to animal damage than the remainder of the embankment and a multitude of small shear failures with scarps 2 to 6 feet high. At two locations on the downstream face of the West Dam, there are unrepaired slope failures, the larger at station 14+50 and the smaller centered on the outlet conduit at station 12+00. These appear to have been caused, at least in part, by high seepage pressures and a high phreatic surface. Water could be seen seeping from the scarp of the larger failure at a distance of up to 6 feet vertically above the embankment toe.

At the time of inspection, the downstream surface of the East Dam was obscured by a snowdrift (see Photo 12), and evidence of seepage was impossible to obtain. Seepage from the West Dam was considerable, even though the maximum head difference between the reservoir and the toe of the dam was only 13 feet. The quantity of water seeping under or through the West Dam at the time of the inspection was estimated to be between 20 and 40 cubic feet per minute. There was free water standing below the toe of the West Dam from station 12+00 to station 20+00. The soil type and seepage forces combine to make the existing conditions on the downstream face and at the downstream toe of the West Dam extremely dangerous, requiring an immediate temporary remedy, followed by a detailed investigation and analysis and any necessary modifications of the remedy. An investigation of the East Dam needs to be conducted to determine whether any remedial steps are needed to provide required stability.

According to Gary Voldseth, the owner's son, an attempt was made a few years ago to seal a portion of the reservoir with Bentonite. The degree of success is not known.

2.3.3 Stability

The presence of unrepaired slope failures in the downstream face of the West Dam associated with an apparent high phreatic surface, indicates that the dam is in imminent danger of failure under the condition of steady seepage from the maximum pool. For this condition the safety factor of the downstream slope is estimated to be nearly 1.00. A safety factor of 1.5 is recommended by inspection guidelines. No stability evaluation of the East Dam could be made at the time of the inspection due to snow cover on the downstream toe area.

The existence of failures in the downstream face of the West Dam requires an immediate temporary remedy, followed by a detailed investigation, analysis, and any necessary modifications. We recommend the investigation and analysis also include the East Dam. The investigation and analysis needs to be performed and the remedy selected with full consideration of the seepage problems, the apparent marginal stability of West Dam under normal pool conditions and potential earthquake effects.

Riprap coverage is inadequate both in thickness and in extent. Although new riprap is apparent in some locations, most notably in the vicinity of the gate tower of the West Dam, it is completely absent above the normal high-water line on about half of the West Dam and all of the East Dam. In unprotected areas the crest of the West Dam has eroded as much as 5 feet toward the centerline (see Photo 7) and the crest of the East Dam has eroded as much as 10 feet, with no recent repairs visible (see Photo 13 and Plate 2).

2.4 PROJECT OPERATION AND MAINTENANCE

2.4.1 Dams

There is no formal plan for performing periodic maintenance of the Voldseth Dams. Maintenance appears to be performed on a piecemeal basis. The most notable lack of maintenance is in the two slope failures in the West Dam. The grass of at least one season is growing on the slide masses and no corrective measures have been taken. The slope failure at the conduit outlet of the West Dam has bent and split the conduit. No repairs have been attempted.

Further lack of proper maintenance is evident in the area of upstream slope protection for both dams. Wave damage on both embankments due to inadequate riprap protection threatens the integrity of the embankments. Wave erosion penetration reaches nearly to the centerline of the East Dam (see Photo 13).

Rodent burrows constitute additional indication of deficient maintenance. There are numerous rodent burrows on all surfaces of both dams. Rodent control should be a part of any formal maintenance plan.

Gary Voldseth stated that the trees and brush at the high-water line on

both dams were sprayed with brush killer three times in 1978. A random check at the time of the inspection showed most of the small trees and brush to be dead. Several large trees were still alive on both dams.

A broken bearing collar was noted at the top of the gate valve control of the East Dam. Although the valve is operational, the broken bearing could eventually prevent the opening or closing of the valve.

2.4.2 Reservoir

The reservoir level fluctuates seasonally, being low in the winter, full by the start of the irrigation season, and low again by autumn. Water is obtained through a diversion canal from Comb Creek. Both dams have outlets controlled by gate valves for the release of irrigation water. There is slight erosion on the shores of the reservoir, however, no remedial action is needed. According to Gary Voldseth, an attempt was made to seal the deepest part of the reservoir with Bentonite within the last few years. There are no gages of inflow, outflow, or reservoir elevation.

2.4.3 Warning System

There is no formal warning system or plan of action to warn downstream inhabitants or interests in the event of impending dam failure.

CHAPTER 3

FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the Voldseth Dams, supplemented by analysis of the project in terms of the recommended guidelines' performance standard, resulted in the following findings:

3.1.1 Size, Hazard Classification and Safety Evaluation

East Dam (MT-1590). This dam is 17 feet high and impounds approximately 1925 acre-feet of water at dam crest. In accordance with inspection guidelines, Voldseth East Dam is intermediate in size with a significant downstream hazard potential rating. The recommended spillway design flood (SDF) for this dam is one-half of the PMF. The project can handle only 44 percent of the PMF ordinates without overtopping. Because the dam is incapable of controlling one-half of the PMF without overtopping and causing the dam to fail, Voldseth East Dam does not meet inspection guidelines.

West Dam (MT-1153). This dam is 35 feet high and impounds approximately 3000± acre-feet of water (based on total volume capability). In accordance with inspection guidelines, Voldseth West Dam is intermediate in size with a high downstream hazard potential rating. The recommended spillway design flood (SDF) for this dam is 100 percent of the PMF. Voldseth West Dam will not be overtopped during the PMF; however, on the basis of its physical condition, West Dam is considered unsafe and requires emergency action.

3.1.2 Embankment Dams

Two slope failures in the downstream face of the West Dam were observed during the inspection. Additionally, many small slope failures at the downstream toe of the same dam were found. Failures seem to be related to the large quanity of seepage water and high phreatic surface emerging 2 to 6 feet vertically above the downstream toe which occurs for most of the length of the dam. Based upon the results of our investigation, we conclude that the embankment stability of the West Dam does not conform to the recommended guidelines and the embankment is in need of immediate attention. Most of the downstream face of the East Dam was covered by a snowdrift at the time of the inspection, and a visual evaluation was not possible.

The riprap on both dams, where present, is generally too thin to offer adequate protection. There is no riprap present in about half the area above the high-water level on the West Dam and in all the area above the high-water level on the East Dam. The vertical distance above high-water line is about 3 feet on East Dam and 6 feet on West Dam. Erosion in the unprotected areas above high water has progressed toward the centerline about 5 feet on the West Dam and 10 feet on the East Dam.

Rodent burrows were visible on all exposed surfaces of both dams. Rodent burrows are especially dangerous in dams like the Voldseth dams, where the

embankment material contains very little clay and is, therefore, susceptible to erosion and piping.

3.1.3 Outlet Works

Voldseth Reservoir has two low-level outlets, one in each dam. They consist of 18-inch-diameter corrugated metal pipes with vertical control shafts containing the manual controls and the vertical slide gates. They are computed to have a combined maximum discharge capacity, with the slide gates fully opened, of about 35 cfs at the minimum crest of the East Dam. They are used for irrigation purposes. The downstream end of the West Dam outlet has been bent downward by a slope failure which centered on the conduit (see Photo 5).

The bearing collar was noted to be cracked on the control shaft of the gate on the East Dam.

3.1.4 Spillway and Reservoir Capacity

The spillway is an uncontrolled irregular earth and cobble channel with a crest elevation approximately 3 feet below the crest of the East Dam. Maximum capacity is 100 cfs at the minimum crest elevation of the East Dam (5511.0 feet). The spillway channel would obviously erode downstream of its crest at discharges anywhere near its capacity. The spillway channel is some distance away from the downstream toe of the East Dam at the south abutment. It is our opinion that erosion in the channel would not encroach on the dam.

The flood resulting from the PMP of 72-hour duration for the 1.0 square mile drainage area, including the reservoir, is computed to have a volume of 990 acre-feet. The combination of reservoir surcharge storage and total spilling discharge capacity is insufficient to prevent overtopping of the East Dam during the PMF. The PMF routings indicate the West Dam would not be overtopped.

3.1.5 Operation and Maintenance

Operation and maintenance are performed by Mr. Voldseth and his son, Gary. They both live about 1½ miles below the reservoir and visit the site when necessary. Water is diverted to the reservoir from Comb Creek. It is then released as needed for irrigation through the low-level outlets of either the East or West Dams. As a consequence, the reservoir level fluctuates seasonally.

Maintenance of the dams is not adequate. Slope failures in the downstream slope of West Dam have existed for a least a year with no visible attempts to repair. There is extensive rodent infestation. Trees and brush on the upstream faces of the embankments have not been regularly removed. Although some riprap has been added in some critical areas, there is serious, unrepaired erosion on crests and upstream faces of both dams.

There is no formal warning system or plan of action to alert downstream inhabitants in the event of dam failure.

3.2 RECOMMENDATIONS

1. Immediately develop, implement and periodically test an emergency warning plan to alert persons and downstream interests in event of imminent structural failure.

2. Immediately hire a qualified engineer to develop and implement interim measures to provide adequate embankment stability and a new reservoir operating plan that maintains the reservoir level not higher than 18 feet below the top of West Dam while interim embankment modifications are being constructed.

3. Conduct engineering studies to determine satisfactory remedies for the demonstrated instability of the West Dam in conjunction with a determination of the stability of both dams. The necessary studies involved in the stability evaluation include:

   - Sampling and testing of soils in the dams and their foundations.
   - Installation, maintenance, and evaluation of piezometers in the dams and abutments and along the downstream toes of the dams.
   - A determination of a design earthquake, the potential for liquefaction, and the effect of the design earthquake on long-term stability of the embankments.

4. Until the existing conditions are at least temporarily remedied, institute regular inspections of the downstream face and toe of the West Dam at least once per day, to check for increased seepage, additional slumping, or any other indication of imminent failure. Any such indication would necessitate the evacuation of all downstream inhabitants.

5. Remove all trees, root systems, and brush from the dam embankments and toe areas; backfill and compact all disturbed area with suitable material.

6. Eliminate rodent populations on the dam embankments and repair rodent damage.

7. Repair erosion above the riprap on the upstream faces of both dams. Place bedding material and riprap to the crest of both dams. Place additional riprap in all areas where riprap coverage is inadequate. Recommend selection and placement of the riprap be supervised by an experienced dam engineer.

8. Inspect the outlet conduits. Repair the downstream end of the West Dam outlet conduit and make any other repairs found to be necessary during the conduit inspection.

9. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard below each dam and required spillway capacity and modify the project as studies indicate.

10. Study the left abutment area of West Dam and, if flood waters flowing around this abutment could cause dam safety problems, take appropriate action to protect the area.

11. Conduct periodic comprehensive inspections at least once every 5 years by engineers with experience in dam design and construction.

Prior to performing engineering studies and remedial construction, coordinate the work with the State of Montana Department of Natural Resources and Conservation to insure compliance with all pertinent laws and regulations.

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9. A.R. Southard, "Soils in Montana", Bulletin 621 Montana Agricultural Experiment Station, Montana State University, Bozeman, Montana, Reprint July 1, 1973.

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PHOTO NO. 1
OVERVIEW
VOLDSETH RESERVOIR

(PHOTO 2) Voldseth West Dam. Downstream face.

(PHOTO 3) Large failed area. Seepage in foreground.

(PHOTO 4) Small slumps at downstream toe. Seepage below toe.

(PHOTO 5) Failed area centered on conduit outlet.

(PHOTO 6) Upstream face of West Dam from right abutment.

(PHOTO 7) Erosion near crest of West Dam.

(PHOTO 8) New broken concrete riprap near crest of West Dam.

(PHOTO 9) Diversion inlet at left abutment of West Dam.

(PHOTO 10) West Dam gate tower.

(PHOTO 11) Looking downstream from West Dam.

(PHOTO 12) Voldseth East Dam. Downstream face obscured by snowdrift.

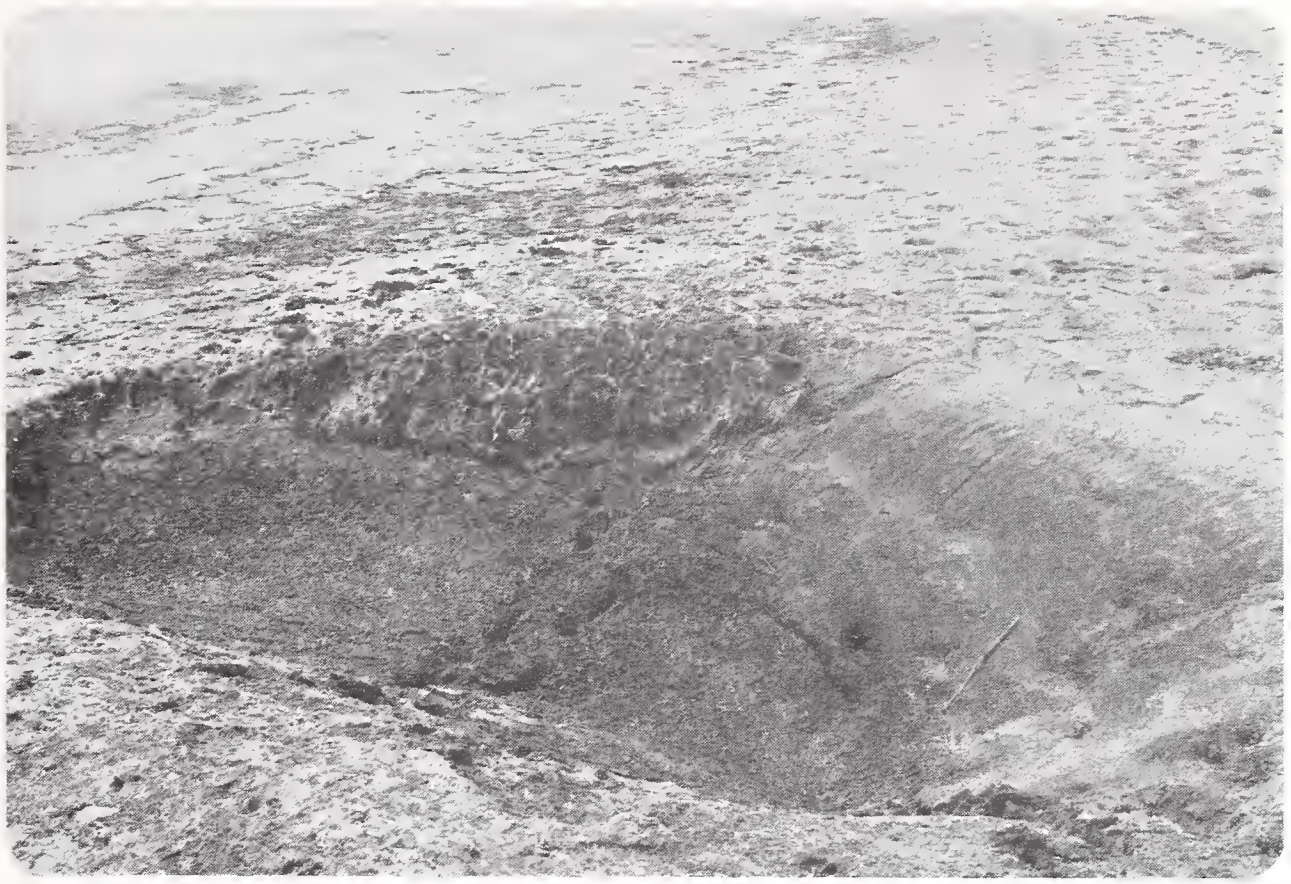
(PHOTO 13) Erosion on upstream face of East Dam.

(PHOTO 14) Upstream face of East Dam from right abutment. Spillway in foreground.

(PHOTO 15) Spillway inlet, looking upstream.

(PHOTO 16) Spillway control section, looking downstream.

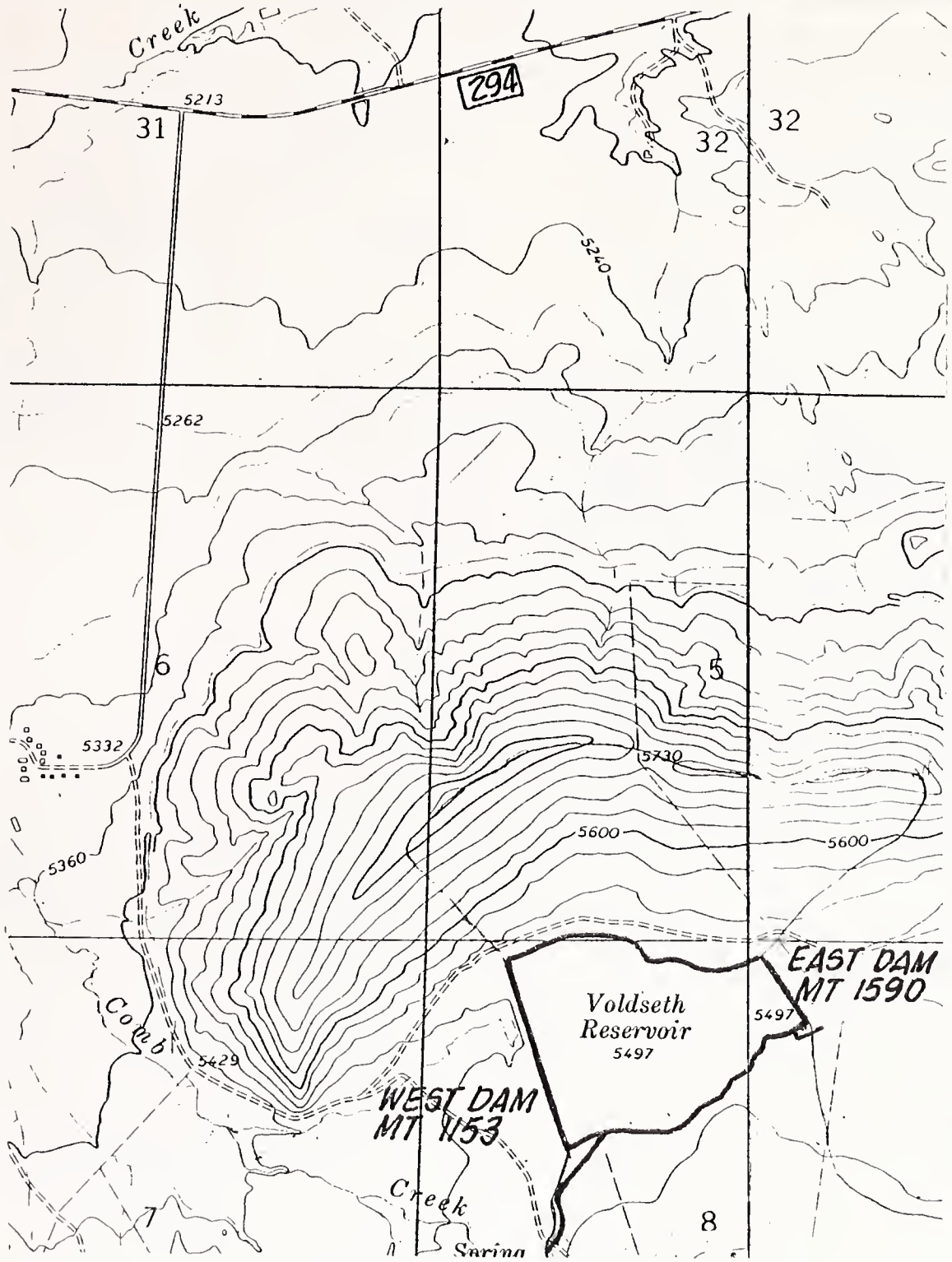
(PHOTO 17) Spillway outlet, looking downstream.



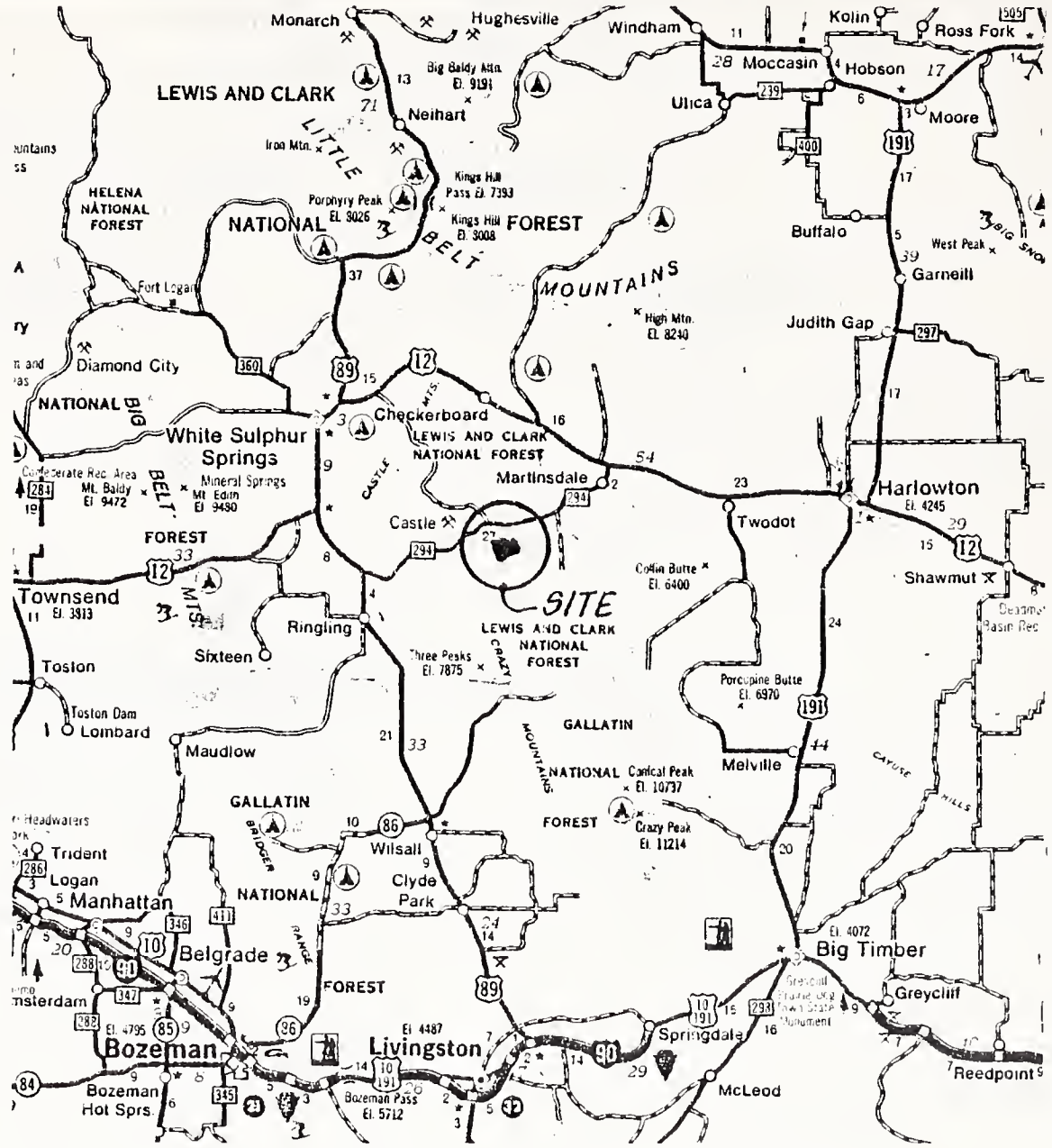
(PHOTO 18) Low-level inlet of East Dam, covered by sediment.

(PHOTO 19) East Dam gate tower.

(PHOTO 20) Looking downstream from East Dam.

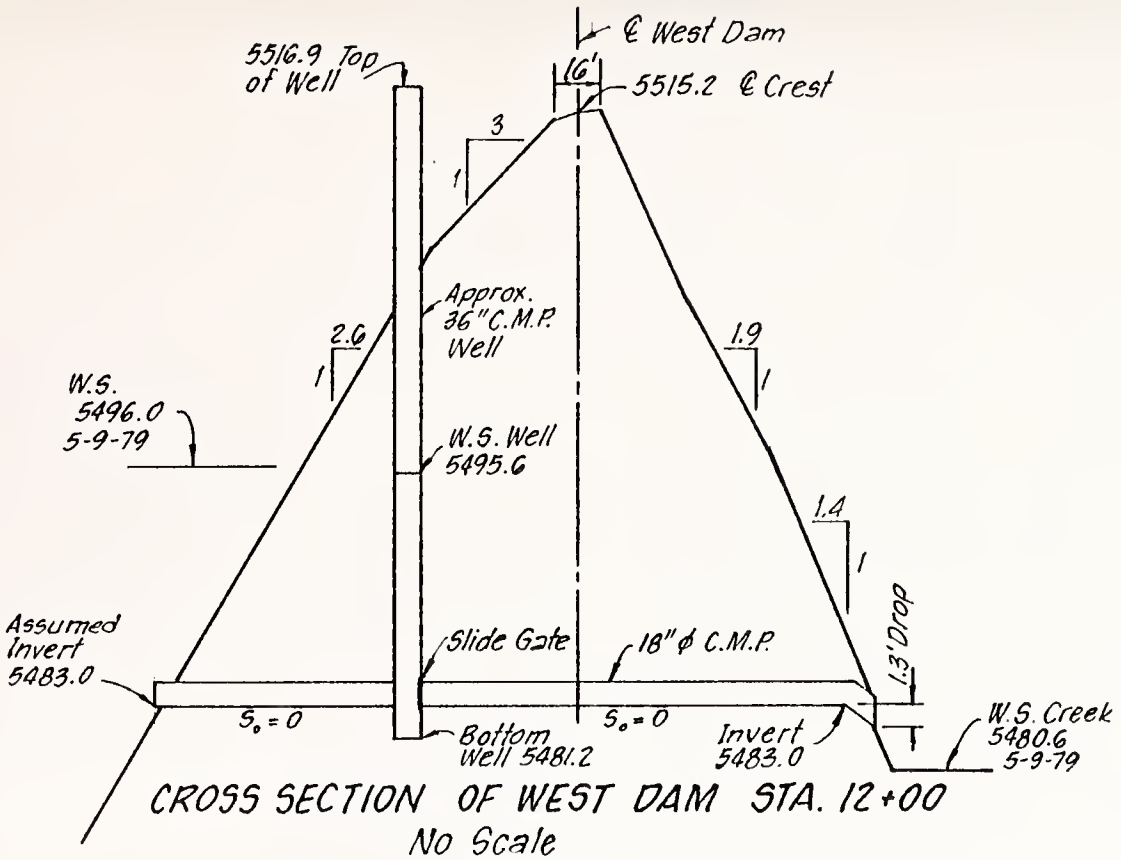


SITE PLAN

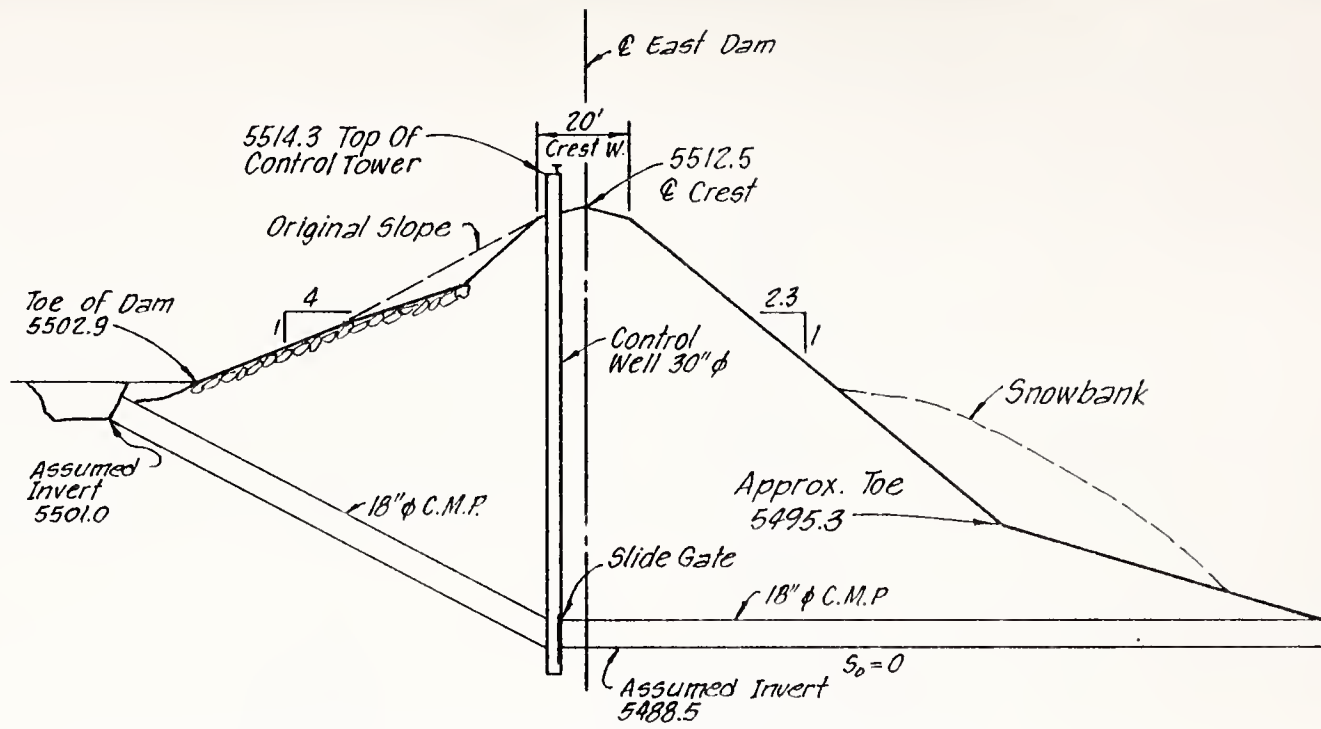


VICINITY MAP

PLATE 1
VOLDSETH RESERVOIR
DAMS
SITE PLAN &
VICINITY MAP



CROSS SECTION OF WEST DAM STA. 12+00
No Scale



CROSS SECTION OF EAST DAM STA. 7+13
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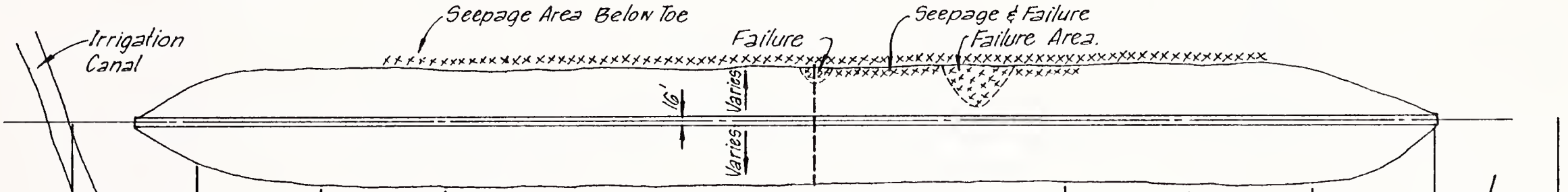
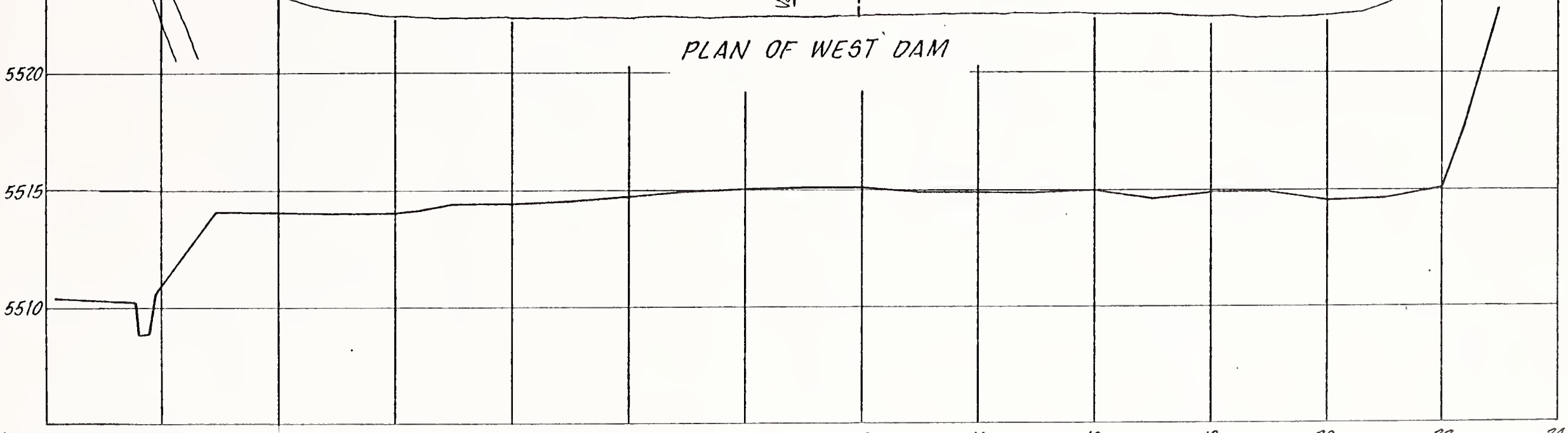


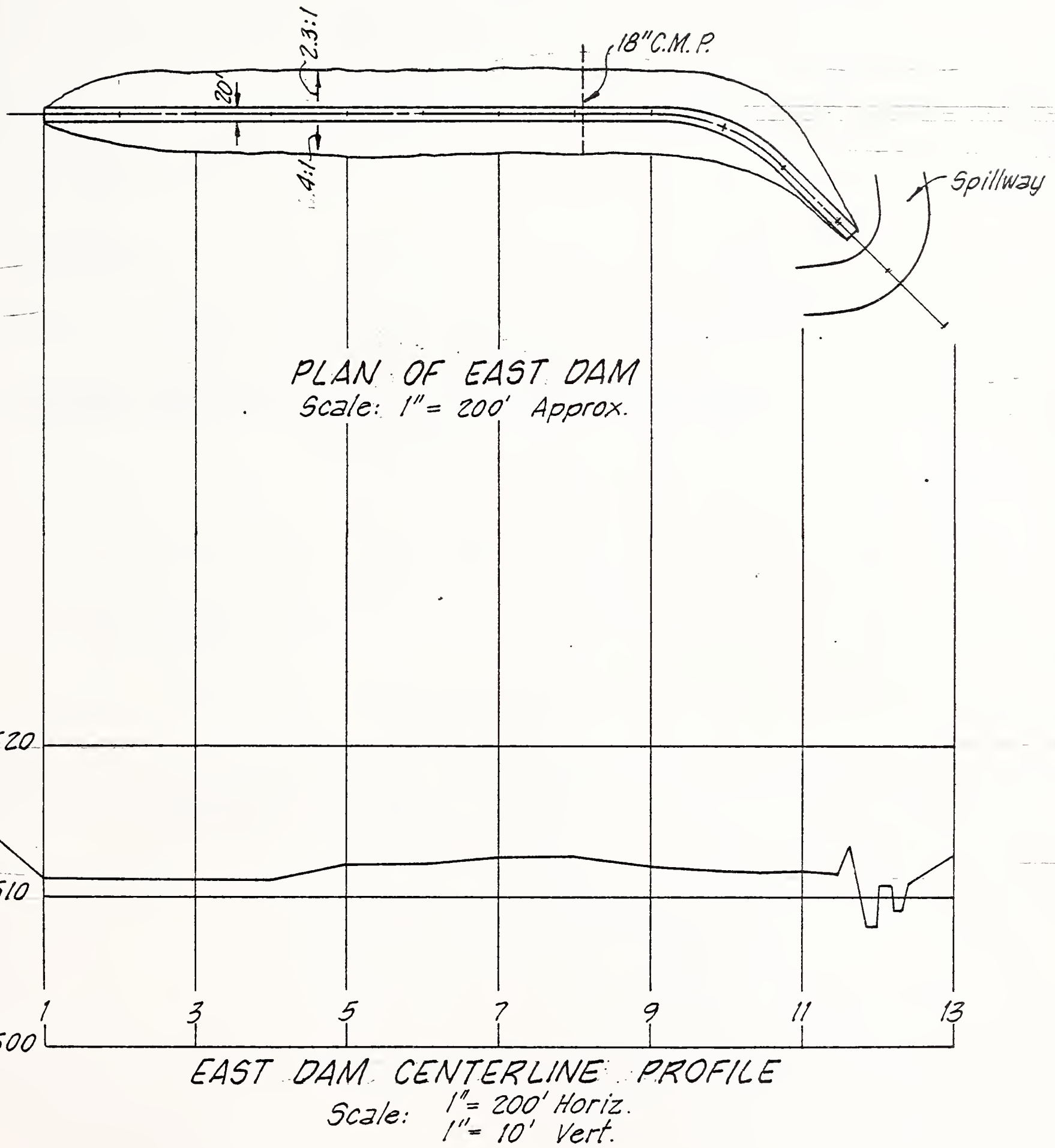
PLAN OF WEST DAM



WEST DAM CENTERLINE PROFILE

PLATE 2

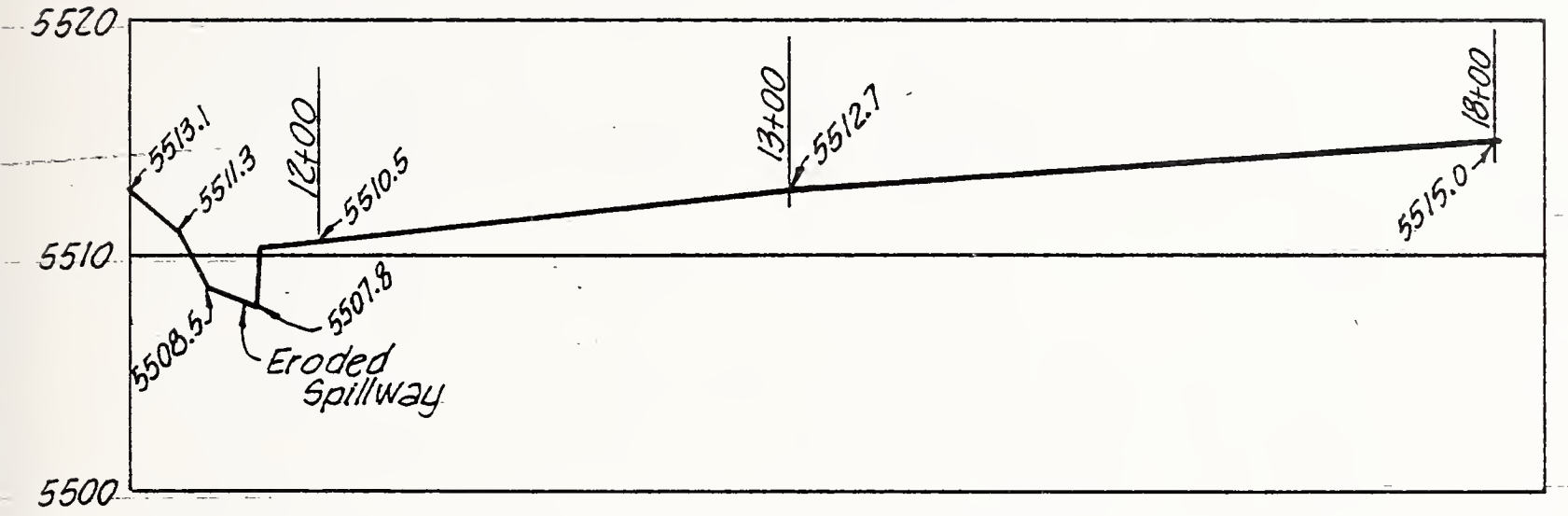
Scale: 1" = 200' Horiz
1" = 5' Vert.



PLAN OF EAST DAM
Scale: 1" = 200' Approx.

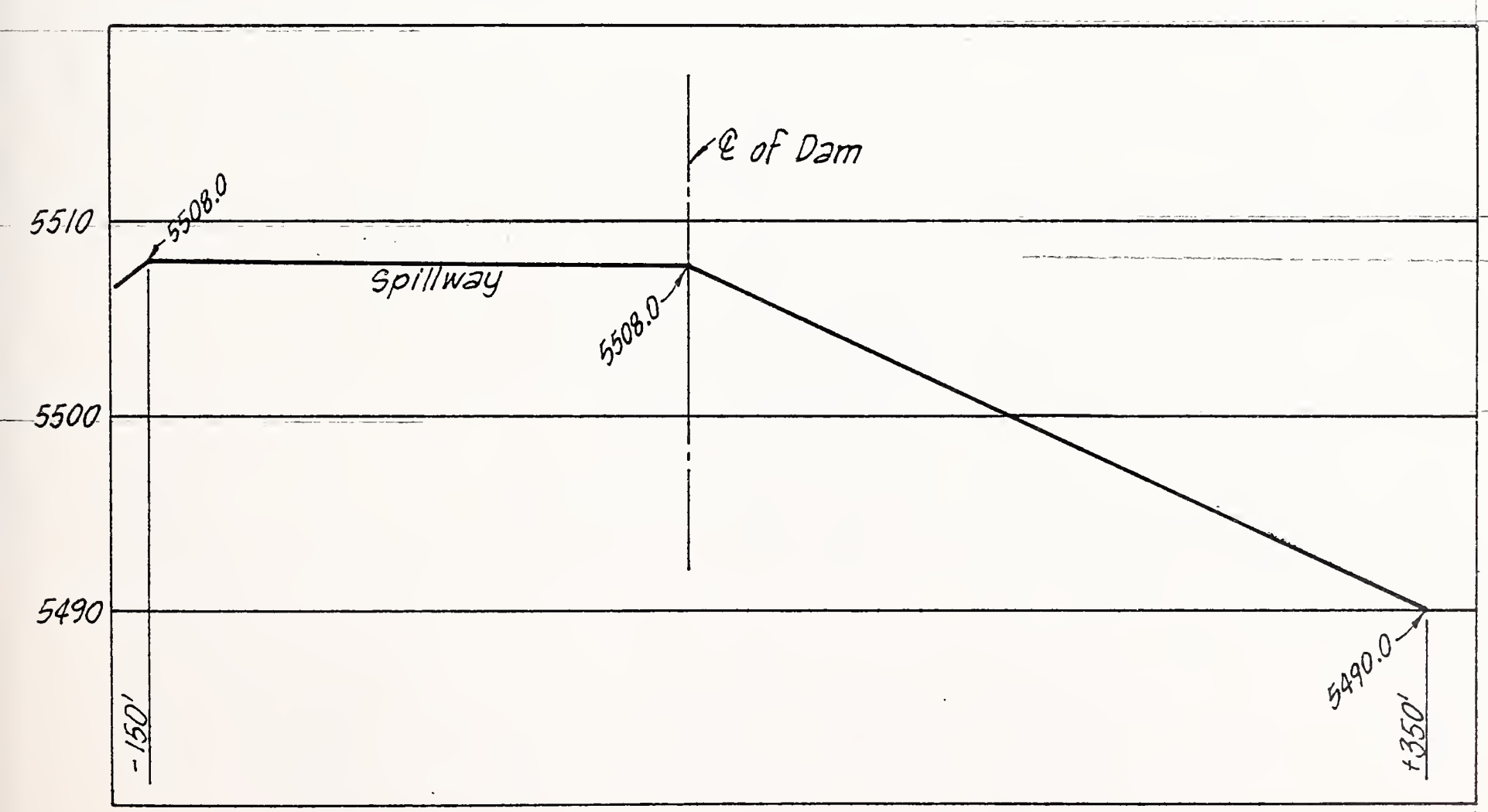
EAST DAM CENTERLINE PROFILE
Scale: 1" = 200' Horiz.
1" = 10' Vert.

PLATE 3



CROSS-SECTION OF SPILLWAY ALONG ℄ DAM

Not To Scale



PROFILE ALONG ℄ OF SPILLWAY

Not To Scale

PLATE 4

GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo, New York
Printed in U S A
SQUARE 10 X 10 TO THE INCH AS-0806 -01

WATER SURFACE AREA, ACRES

160 120 80 40 0

VOLDSETH RESERVOIR ELEV.-AREA-STORAGE CURVES

E Vs AREA

Min. W. Dam 5514.2

Min. E. Dam 5511.3

5520

5515

5510

5505

5500

5495

5490

ELEVATION, FEET

Note: The Spillway Crest Elev. Set to Conform Owners Statement V≥ 1200 A.F.

5507.8
℄ Normal Pool & E. Spillway Crest

E' Vs VOLUME

1000 2000 3000 4000

TOTAL STORAGE VOLUME, ACRE-FT.

PLATE 5

SPILLWAY DISCHARGE RATING CURVE

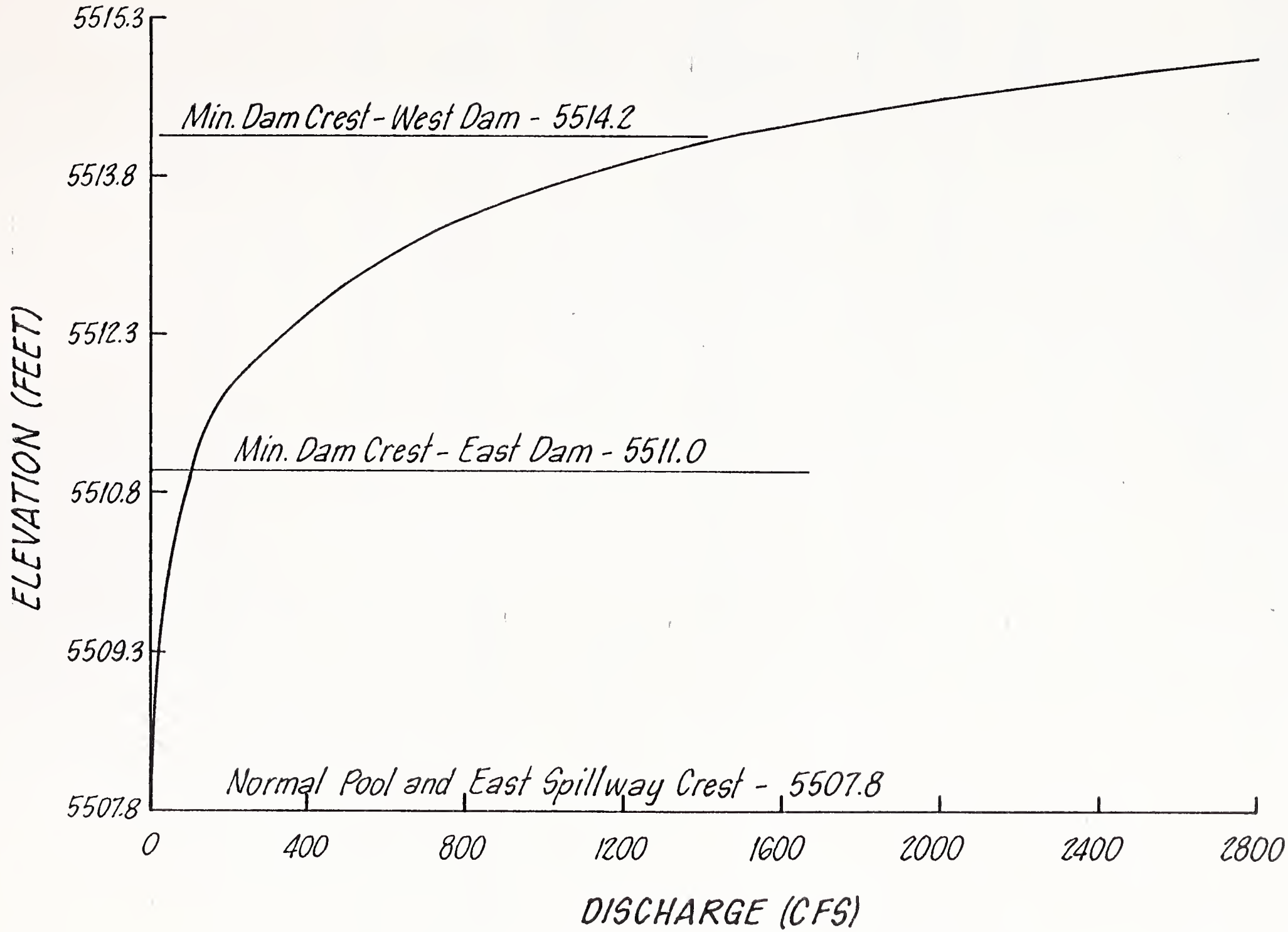


PLATE 6

Commercial Cattle
PHONE 572-3319
AREA CODE 406

GEORGE VOLDSETH RANCH
LENNEP ROUTE
Martinsdale, Montana

20 Dec 1979

Department of the Army
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Attn: Sidney Knutson, P.E.
Asst. Chief, Engineering Division

This is to acknowledge receipt of the final draft report on Voldseth Dams and Reservoir (MT-1153, MT 1590).

As yet I have not had time to study the report in detail but can inform you that we have started repair work on the west dam along the lines that your department and that of the Montana Department of Natural Resources and Conservation have recommended.

We purchased some additional machinery in the form of a 3/4 yard hydraulic backhoe, and have done a considerable amount of drainage work in an attempt to completely drain the pond formed by the lower face borrow pit.

We have also placed a considerable amount of rip-rap on the reservoir face of the west dam and intend to continue work as long as the weather permits.

Will try to submit our comments on the preparation of the final report sometime next month.

Yours truly,
George Voldseth

Cc. to Montana Dept. of Natural Resources and Conservation
Helena, Montana

Encl 6

TG Ranch

Lennep Route

Martinsdale, Montana 59053

Commercial Cattle

Phone (406) 572-3319

or 572-3330

COMMENTS ON THE FINAL DRAFT REPORT ON VOLDSETH DAMS & RESERVOIR
(MT-1153, & MT-1590)

Most of the findings in your final draft report are well taken, however I sense an element of over-reaction that is understandably attributal to a large degree to the failure of the Teton Dam in Idaho. Be that as it may, I will try to confine my comments to honest differences of opinion.

First of all, I take exception to the reference to a volume of seepage above the downstream toe, and the low strength of the clayey to sandy silt embankment materials as demonstrated by the fact that upon excavation of the sloughed area there was no evidence whatsoever, of any seepage through the fill proper. As to the reference to the low strength, the embankment is standing virtually perpendicular which in my judgment would be contrary to the allegation.

As to the reference that failure would endanger lives and cause extensive damage to private residential property, ranch buildings, State Highway #294, and possibly a railroad, I can't conceive of the possibility that even at maximum reservoir level, that the entire storage capacity of the reservoir would be released at once. As to flood damage to the home ranch buildings, the topography of the land below the reservoir contains two ridges that enter the one-half mile wide valley from the east and north-east that would tend to divert any floodwater to the west side of the valley. Below the ranch buildings, the valley continues to widen to where it reaches nearly a mile wide in places. The next place of habitation is approximately four miles below the reservoir so that the crest should be pretty well dissipated by the time it would reach that point. The highway and railroad are also a considerable distance from the reservoir.

In regards to the PMF referred to in the report, it will be a simple matter to enlarge the existing spillway, and we intend to heighten the East Dam to provide more freeboard. Another factor pertaining to the PMF is that the intake canal to the reservoir is approximately one-quarter mile long and has a certain maximum capacity. In the event of a flood that would exceed that capacity, it would and has overtopped the canal embankment and serves as somewhat of a safety valve.

As mentioned in the cover letter, we have already taken steps to correct the rip-rap and brush condition.

As to Principal Recommendations, we have telephone communication, also two-way radio communication with downstream interests in the event it becomes necessary for an alert, for a failure of the West Dam. Failure of the East Dam would not endanger anyone as it would only flood range land.

We have already taken action to correct the unsafe condition of the West Dam as detailed in the cover letter and will continue to do so to the best of our ability and resources.

We have access to at least two graduate Civil Engineers who can give us valuable assistance in correcting our problems.

During my lifetime of nearly sixty-seven years there has not been an earthquake of any consequence in this vicinity.

Respectfully submitted,

George Voldseth

George Voldseth, Pres.
TG Ranch
Lennep Route
Martinsdale, Montana 59053

TG Ranch

Lennep Route

Martinsdale, Montana 59053

Commercial Cattle

Phone (406) 572-3319

or 572-3330

8 March 1980

RE; Voldseth Dams & Reservoir (MT-1153, MT-1590)

Department of the Army
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Attn: Sidney Knutson, P.E.
Asst. Chief, Engineering Division

Since my letter to you of 20 Dec 1979, it would probably be in order to give you a more detailed and up to date progress report along the lines of recommendations as set forth in your final draft report.

As mentioned in the above letter, we have completed about one-half mile of drainage and outlet canals to confine the water released from the dam outlet works and the complete drainage of the West Dam downstream borrow pit. We have also excavated the entire sloughed area of the major slide to an elevation of six to eight feet below the original ground line. From the original ground line downward for a distance of three to four feet, we encountered typical top soil. Then below that, we encountered a two to three foot layer of gravel, that apparently, is the strata that carries the seepage water. On continuing the excavation downward for test purposes, we encountered a bluish-purple layer of impervious clay that was relatively dry of moisture.

We then began excavating a toe trench from the main slough area southward towards the outlet works. After proceeding about forty feetin this direction at a depth just below the gravel seam, the weather dropped to between thirty and forty below zero which resulted shutting down the project until the elements become more favorable. I can assure you that we will resume operations as soon as the conditions become more favorable.

We have purchased the necessary drain tile and have added considerable rip-rap to the west dam as well as practically all the brush removable on both dams. We also intend to make concerted effort at rodent extermination in the drainage area.

I can assure you that we will make every effort to come within compliance of your recommendations that our resources will permit.

Yours truly,

George Voldseth

George Voldseth Pres.
TG Ranch

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

14 April 1980

Mr. George Voldseth
TG Ranch
Lennep Route
Martinsdale, Montana 59601

Dear Mr. Voldseth:

We have received your comments on the draft dam safety report on Voldseth Dam and certainly appreciate your sincere interest in correcting the unsafe condition of the West Dam. However, we urge you to review, discuss and coordinate the report recommendations with the Engineering Bureau of the Montana Department of Natural Resources and Conservation (DNR & C). Correcting the stability problems at your project requires the advice and supervision of a competent geotechnical engineer experienced in this type of work.

Our probable maximum flood (PMF) derivation is an estimate based on accepted procedures and represents what could happen. Refinement of our estimate is a recommendation that could either increase or decrease the final flood characteristics. The detailed PMF study should consider all pertinent factors, including the intake canal to the reservoir. We will include a recommendation in the final report to perform a hydraulic routing of a dam breach hydrograph to more accurately establish the downstream hazard potential and effects of dam failure.

Again, we suggest that prior to any further action you coordinate with the DNR & C.

Sincerely yours,

Edward for

SIDNEY KNUTSON, P.E.
Asst. Chief, Engineering Division

Copy furnished:
Mr. Glen McDonald
Montana DNR & C
32 South Ewing
Helena, Montana 59601

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

January 3, 1980

Department of the Army
Seattle District Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Attn: Ralph Morrison

Re: Review of final draft of Dam Safety Inspection report by Hoskins, Western, and Sonderegger, Inc. on Voldseth Dams. (MT - 1153 and MT - 1590)

Dear Ralph:

We have reviewed the above referenced report. Following are our comments:

(1) In the Executive Summary on page i, in the third sentence the the surface area of the reservoir is noted as being 108. No units are given.

(2) In Chapter 3, under sub-section 3.1.1, reference is made to a ranch building which is located approximately 200 feet downstream of the east dam. This building is not a factor in establishing the hazard potential for this dam as it is uninhabited and is in fact a horse barn. The nearest residence in the floodplain is approximately 4 miles downstream.

We believe that consideration should be given to performing a breach and downstream routing analysis on the east dam under spillway design flood conditions to study the effects of flooding downstream. This might indicate a lower hazard potential classification for this dam.

(3) In the Executive Summary on page ii, in the second paragraph, it is stated that the spillway will handle 37 percent of the PMF. It should be noted whether reference is being made to the PMF total volume or PMF maximum ordinate. It is preferred that the spillway be rated in terms of a percentage of the PMF maximum ordinate which the spillway will pass before the dam is overtopped in lieu of a percentage of the PMF total volume.

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(4) In the Executive Summary on page ii, in the last paragraph, it is noted that most of the trees and brush on both dams are dead. This is not the case, as during our visit of the site on July 17th of this year it was found that there are several full grown trees on the west dam which are very much alive along with two very large trees on the east dam which are also alive.

(5) In the Pertinent Data on page iv, surcharge storage is shown as being 349 acre-feet. This should be 351 acre-feet.

(6) In Paragraph 2.2.4 on page 17, it is stated that the total volume of the PMF was 52,996 cfs. Should it instead be 52,996 acre-feet? In any case this number seems high for a 1 square mile drainage area.

(7) In sub-section 2.3.1 Dam Embankments, should the sentence "Some weathered shale was obtained from above the right reservoir area" be deleted?

(8) On page 22 in the third paragraph, the statement that most of the trees and brush on both dams are dead is incorrect.

(9) In sub-section 3.1.1, second paragraph, it is stated that the West Dam impounds approximately 3000± acre-feet. This is misleading as the east dam controls the reservoir maximum capacity at 1925 acre-feet.

Thank you for the opportunity to review and comment on the final draft report on Voldseth Reservoir dams.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:mb